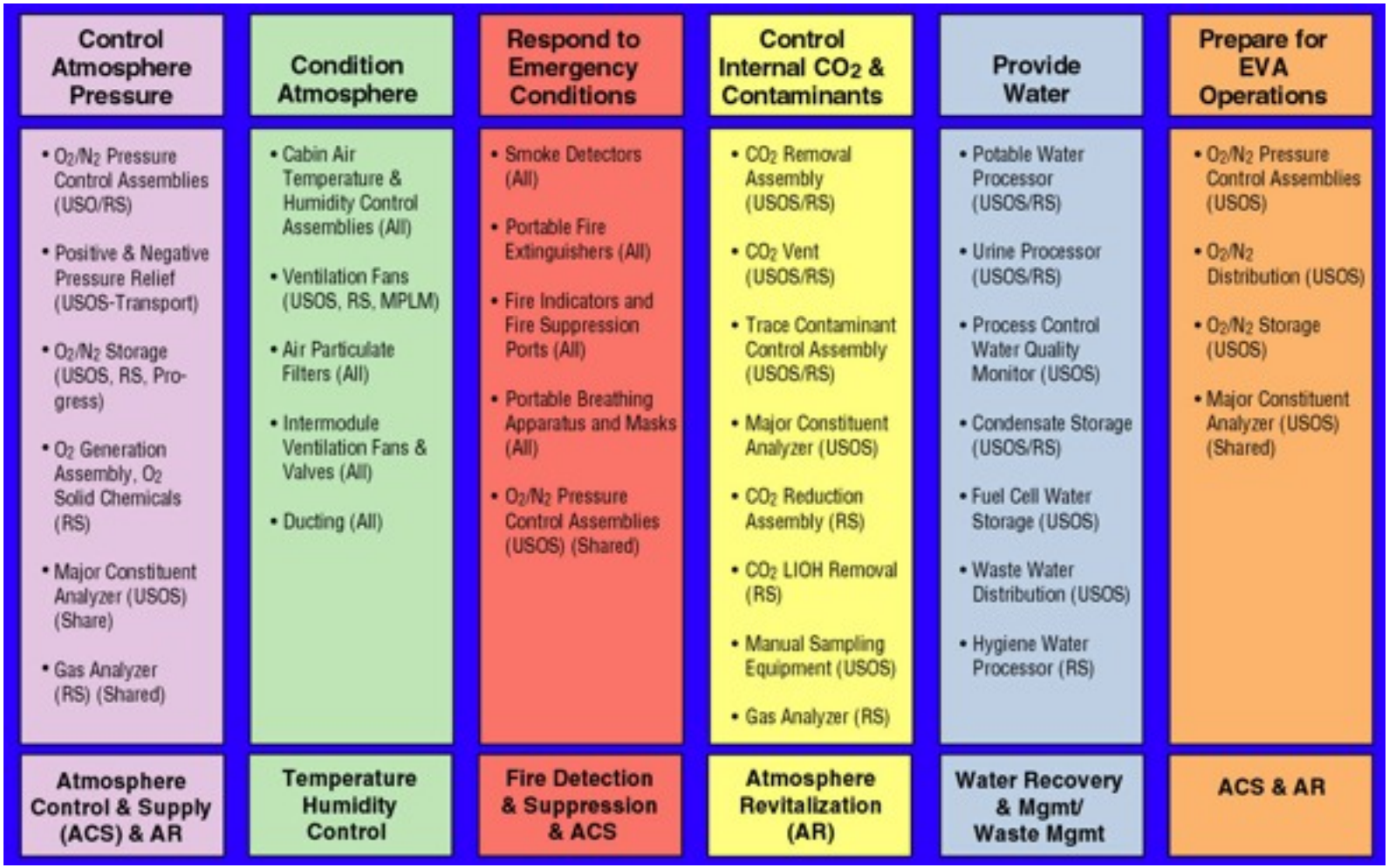
International Space Station Environmental Control and Life Support

Monsi Roman
NASA/Marshall Space Flight Center

Agenda

- Environmental Control and Life Support Systems- What is it?
- What kind of waste are we designing for?
- ISS Urine Processor
- ISS Water Processor
- Overview Challenges
- The Future
- Back-up Charts

ECLSS- What is it?



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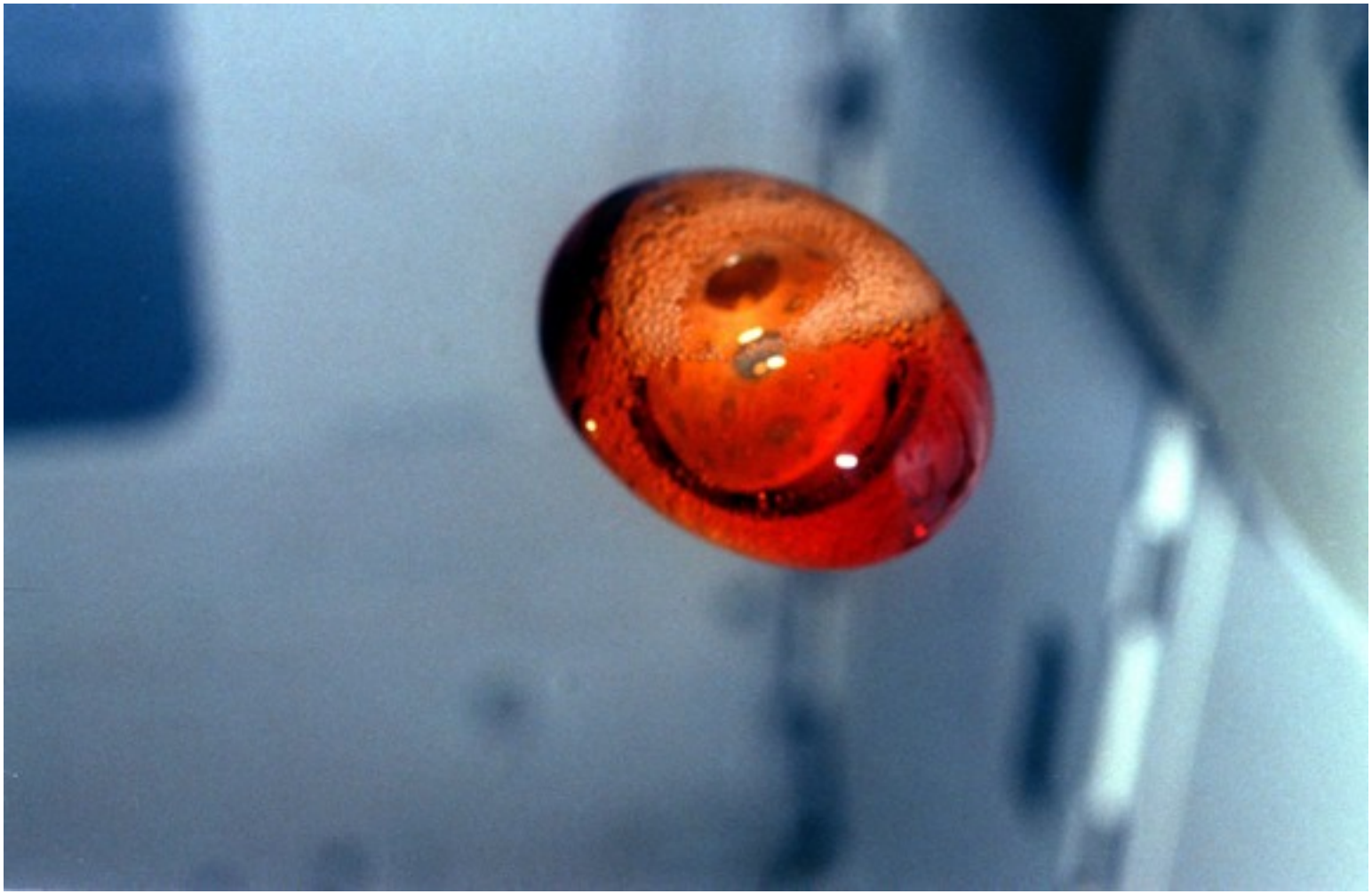
THE ECLS CHALLENGE

Needs

- Oxygen = 0.84 kg (1.84 lb)
- Food Solids = 0.62 kg (1.36 lb)
- Water in Food = 1.15 kg (2.54 lb)
- Food Prep Water = 0.76 kg (1.67 lb)
- Drink = 1.62 kg (3.56 lb)
- Metabolized Water = 0.35 kg (0.76 lb)
- Hand/Face Wash Water = 4.09 kg (9.00 lb)
- Shower Water = 2.73 kg (6.00 lb)
- Urinal Flush = 0.49 kg (1.09 lb)
- Clothes Wash Water = 12.50 kg (27.50 lb)
- Dish Wash Water = 5.45 kg (12.00 lb)
- Total = 30.60 kg (67.32 lb)

Effluents

- Carbon Dioxide = 1.00 kg (2.20 lb)
- Respiration & Perspiration Water = 2.28 kg (5.02 lb)
- Food Preparation, Latent Water = 0.036 kg (0.08 lb)
- Urine = 1.50 kg (3.31 lb)
- Urine Flush Water = 0.50 kg (1.09 lb)
- Feces Water = 0.091 kg (0.20 lb)
- Sweat Solids = 0.018 kg (0.04 lb)
- Urine Solids = 0.059 kg (0.13 lb)
- Feces Solids = 0.032 kg (0.07 lb)
- Hygiene Water = 12.58 kg (27.68 lb)
- Clothes Wash Water
  Liquid = 11.90 kg (26.17 lb)
  Latent = 0.60 kg (1.33 lb)
  Total = 30.60 kg (67.32 lb)



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5

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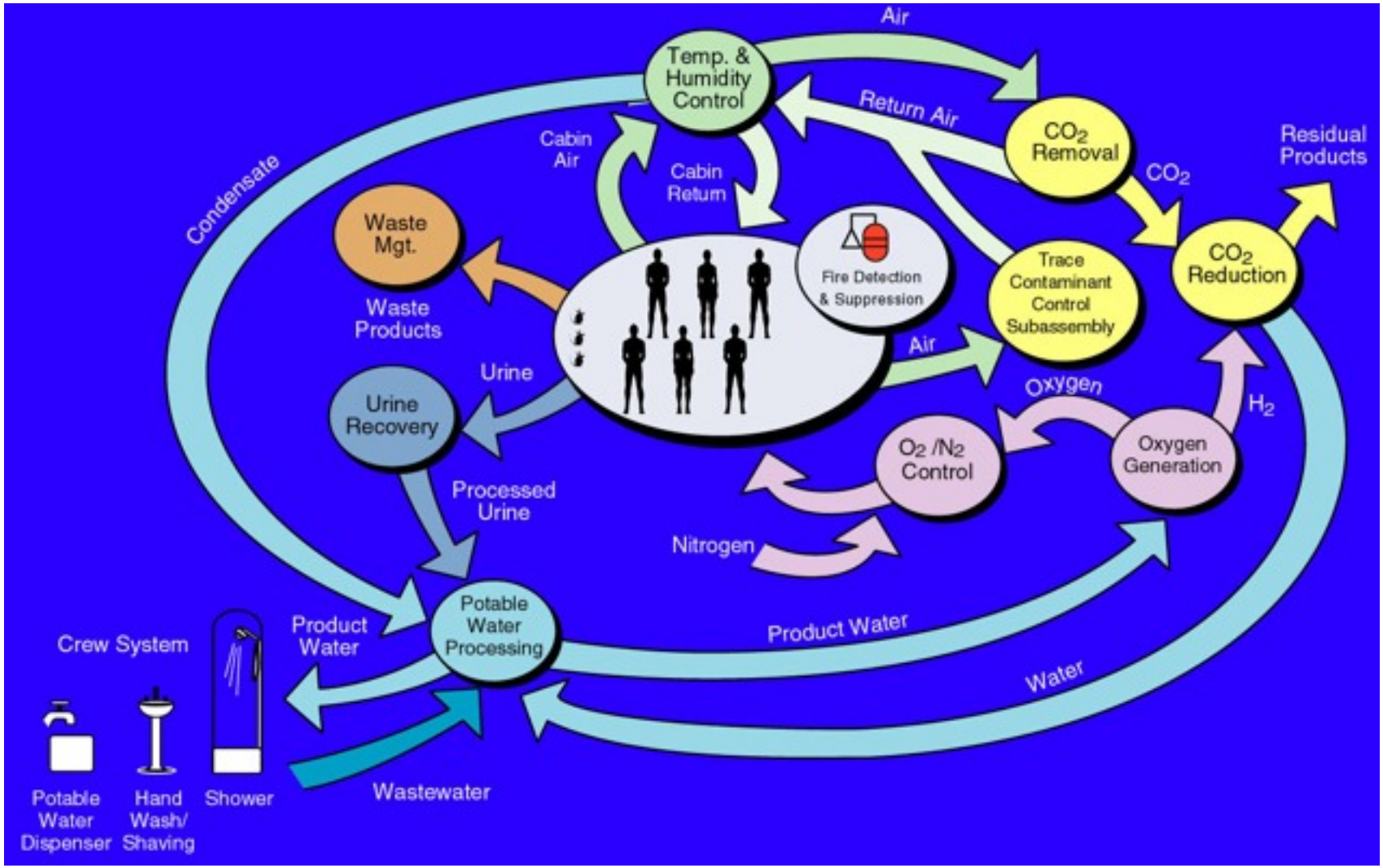
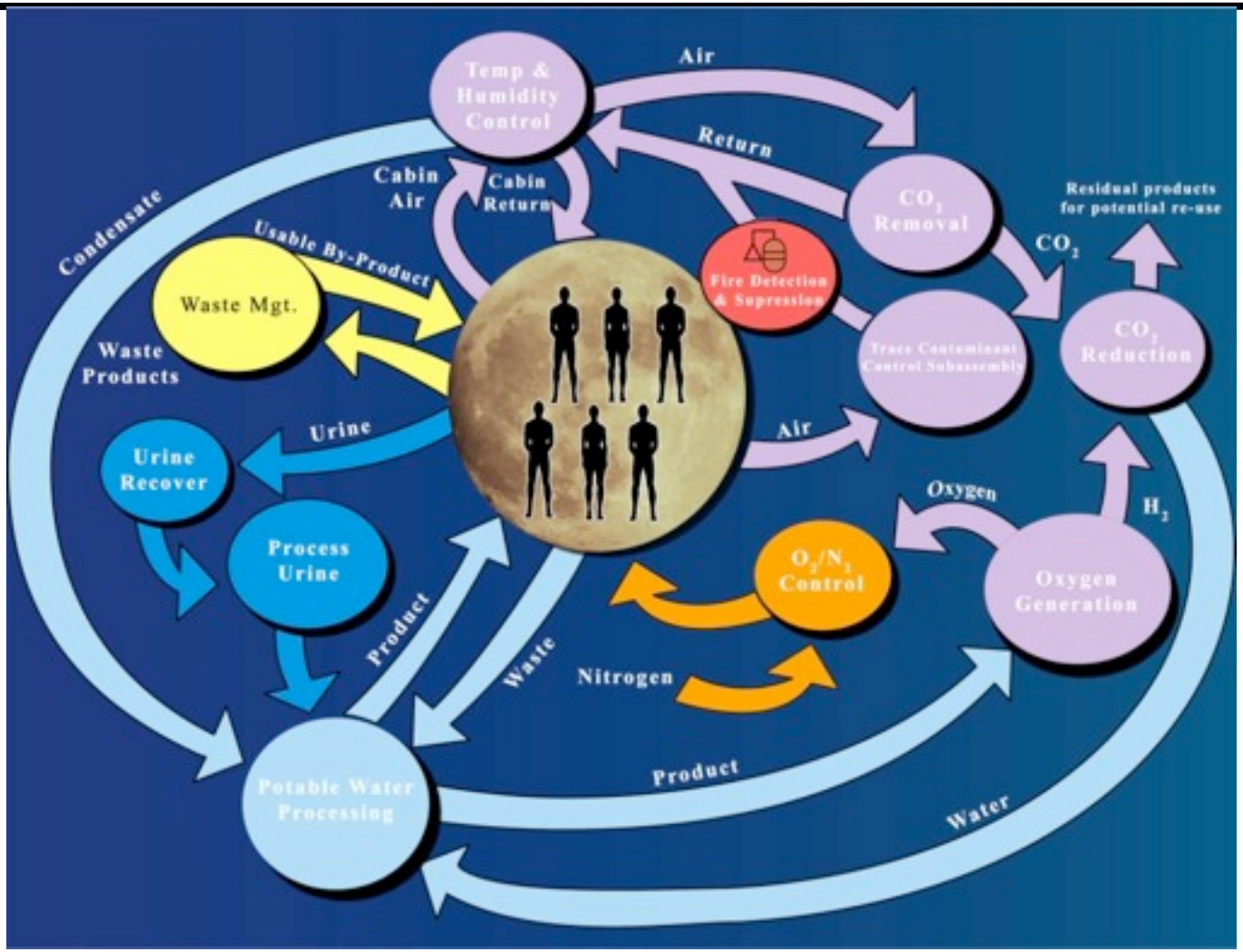
The Life Support Loop



The Goal: Closing the Loop



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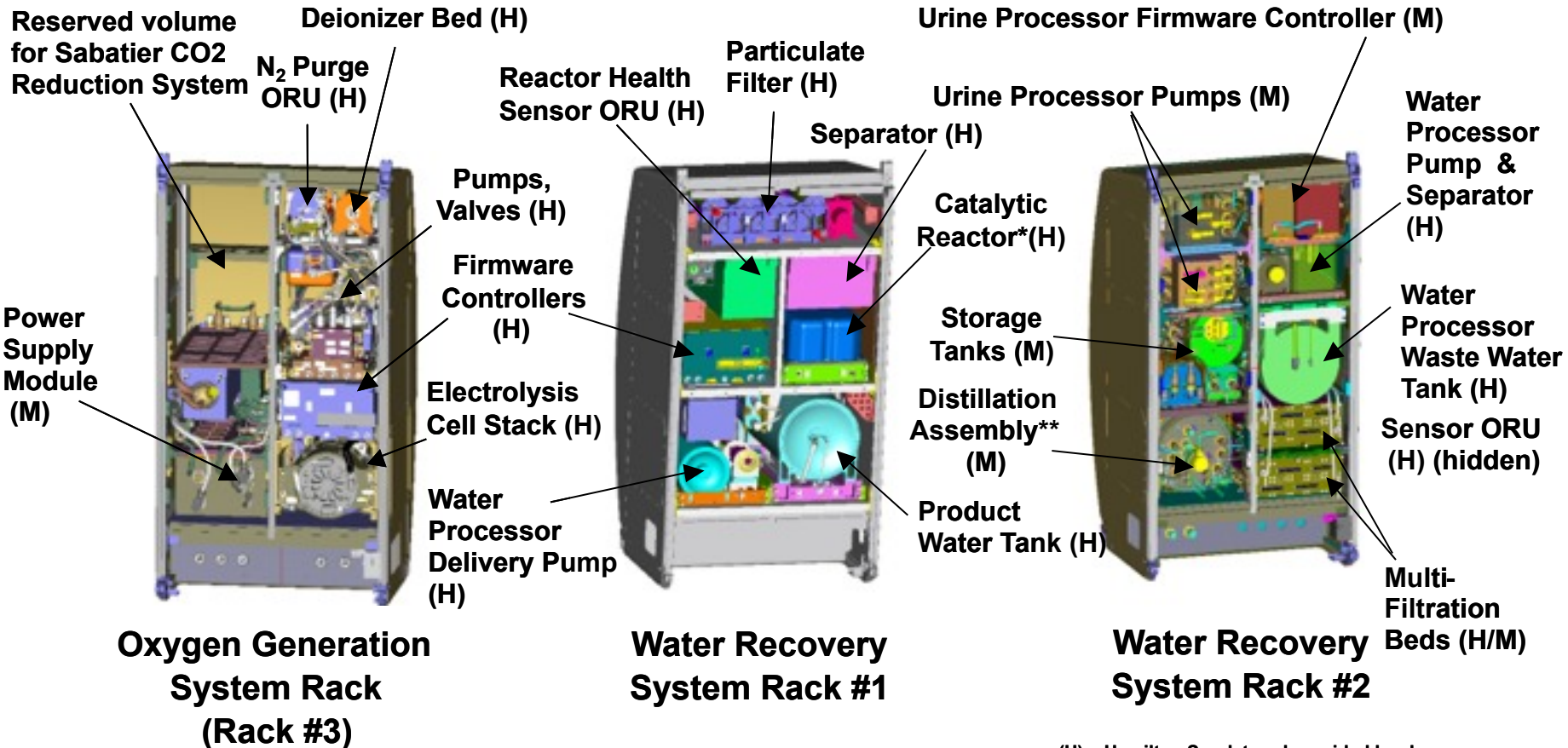
7

Regenerative ECLSS Racks



(H) = Hamilton Sundstrand provided hardware
(M) = MSFC provided hardware
Hamilton Sundstrand responsible for rack analytic integration for WRS#1
MSFC responsible for rack analytic integration for WRS#2 & OGS racks, physical integration for all 3.

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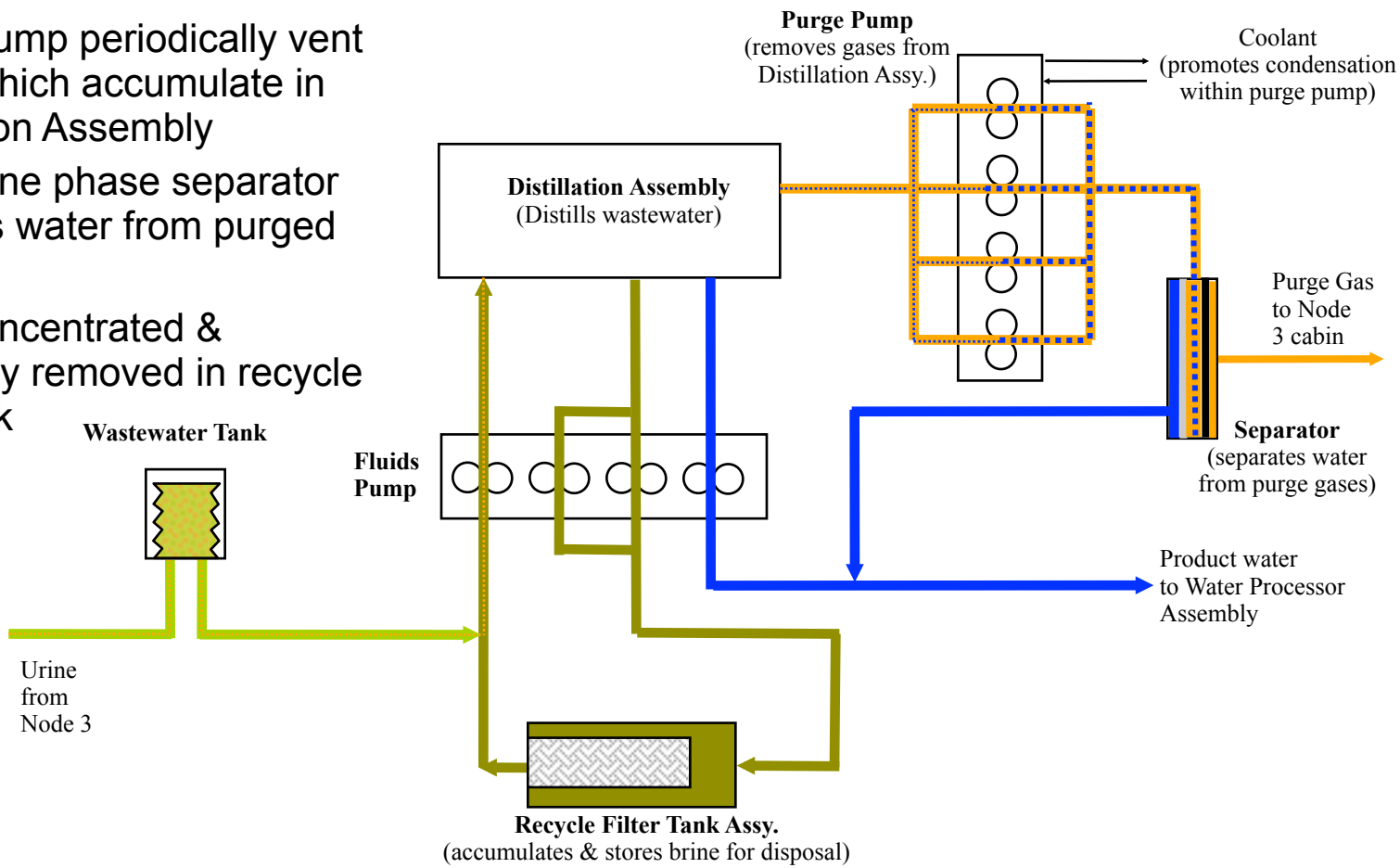
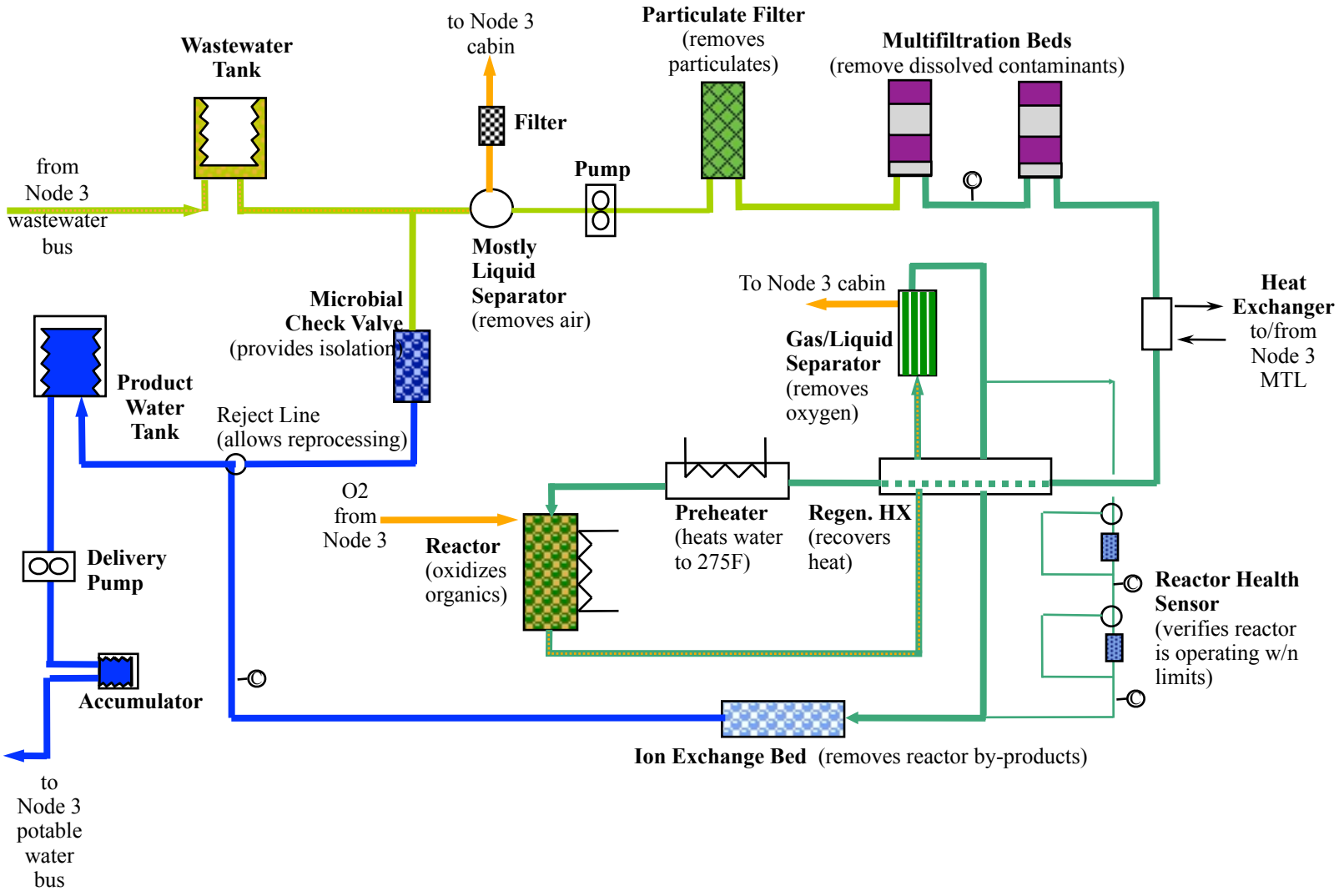
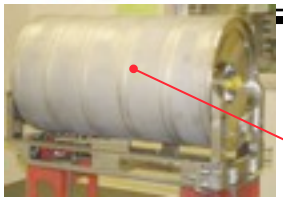
Urine Processor Description

- **Integrated Process**
  - » Ambient temperature, low pressure distillation
  - » Pretreated urine temporarily stored prior to processing
  - » Purge pump periodically vent gases which accumulate in Distillation Assembly
  - » Membrane phase separator recovers water from purged gases
  - » Brine concentrated & ultimately removed in recycle filter tank



ISS Water Processor Description

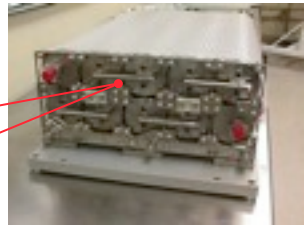




to Node 3 cabin

Particulate Filter (removes particulates)

Multifiltration Beds (remove dissolved contaminants)



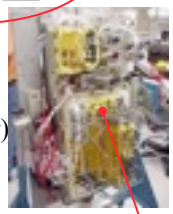
Wastewater Tank

Filter

Pump

from Node 3 wastewater bus

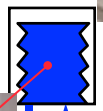
Mostly Liquid Separator (removes air)



To Node 3 cabin

Heat Exchanger to/from Node 3 MTL

Microbial Check Valve (provides isolation)



Product Water Tank

Reject Line (allows reprocessing)

Gas/Liquid Separator (removes oxygen)

O2 from Node 3

Reactor (oxidizes organics)

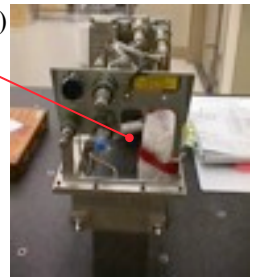
Preheater (heats water to 275F)

Regen. HX (recovers heat)

Delivery Pump

Accumulator

Reactor Health Sensor (verifies reactor is operating w/n limits)



to Node 3 potable water bus

Ion Exchange Bed (removes reactor by-products)

Biofilm Challenges in Space

Wetted Materials in space life support systems include:

- Titanium
- 316L Stainless Steel
- Teflon
- Viton O-rings
- Nickel-Brazed Stainless Steel

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ECLS Challenges

- **Urine/water (potable/wastewater) Hardware Health/Performance**
  - » Design life (10 years or more)
  - » Triple containment
  - » Control of biofilm and corrosion/MIC on wetted surfaces
    - Conditions in flight hardware difficult to assess
  - » Control of fungal growth in pretreated urine
  - » Separating steam from liquid/ gas from liquid
  - » Flow rates: low, intermittent or no flow
  - » Dead-legs
  - » Potential long term storage of water in Teflon bags
  - » Limitations with the use of antimicrobials
  - » What to do with the by-products/waste

ECLS Challenges (cont.)

- **Urine/water (potable/wastewater)**
  - » Gravity/microgravity effects
    - pumps/valves
    - Back-contamination
  - » Wastewater in narrow tubes
  - » Storage/Holding time (between sample and analysis)
  - » Control of microorganisms in potable water
    - Re-growth potential/resistance to antimicrobials
    - MIC

ECLS Challenges

15

ECLS Challenges

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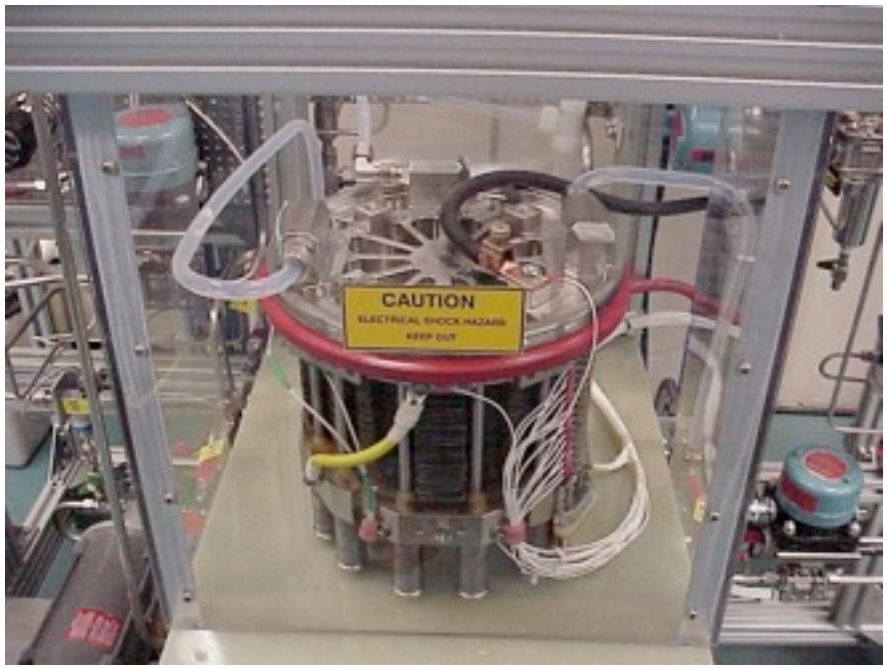
16

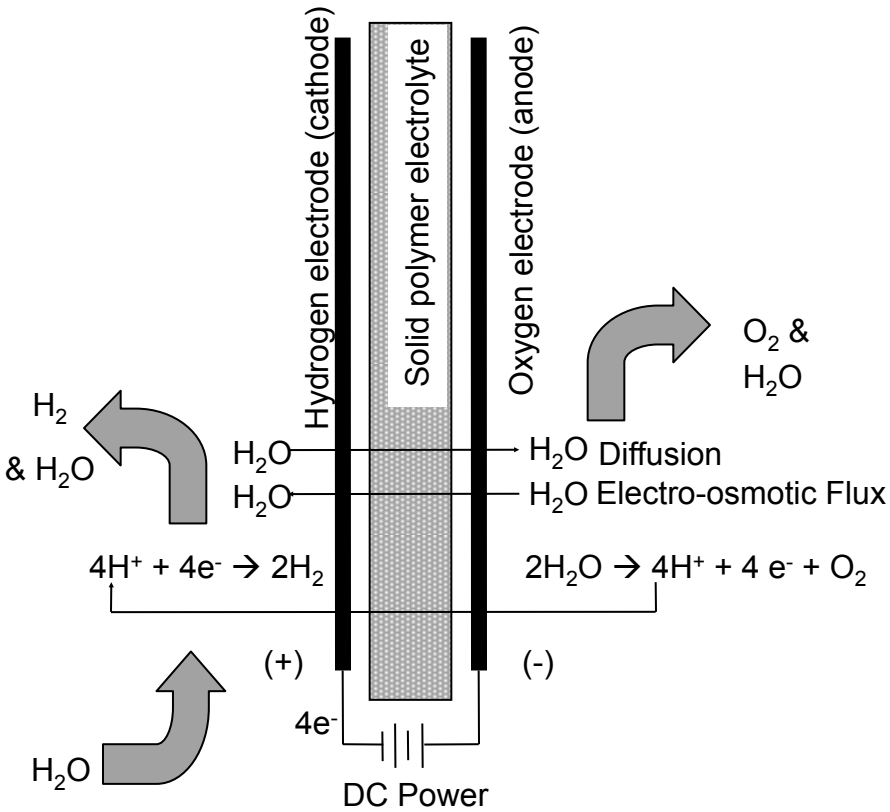
Space Station Oxygen Generator

- **Core Technology: Solid Polymer Electrolysis (cathode feed)**

Cell Stack

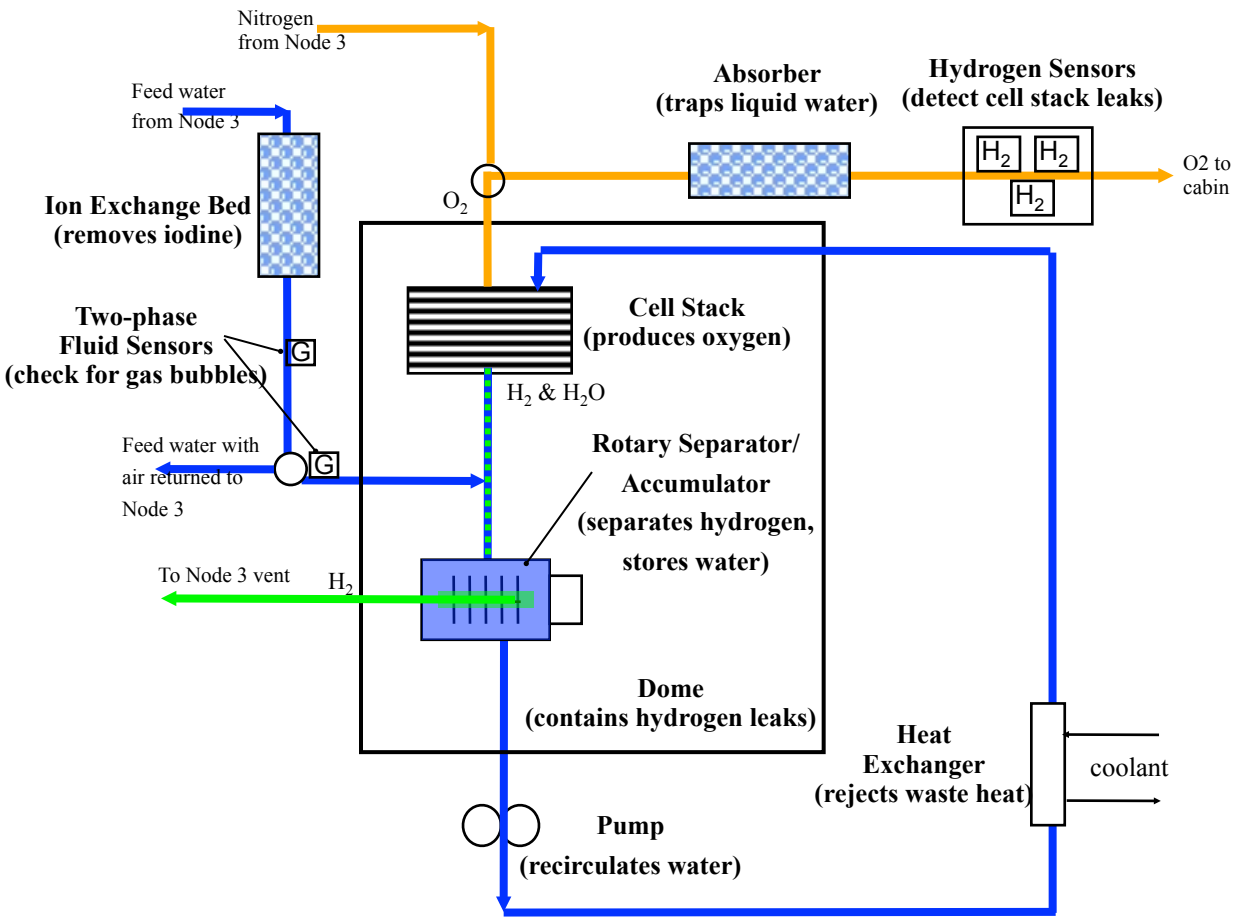


Electrolysis Cell Reactions



Oxygen Generator Description

- **Integrated Process**
  - » Oxygen & hydrogen produced in 28-cell stack
  - » O_2 delivered to cabin
  - » H_2 mixed with excess re-circulated water, separated dynamically, and vented overboard (ISS baseline)
  - » Makeup water periodically added and stored within rotary separator
  - » Oxygen lines purged with nitrogen for safety after shutdowns

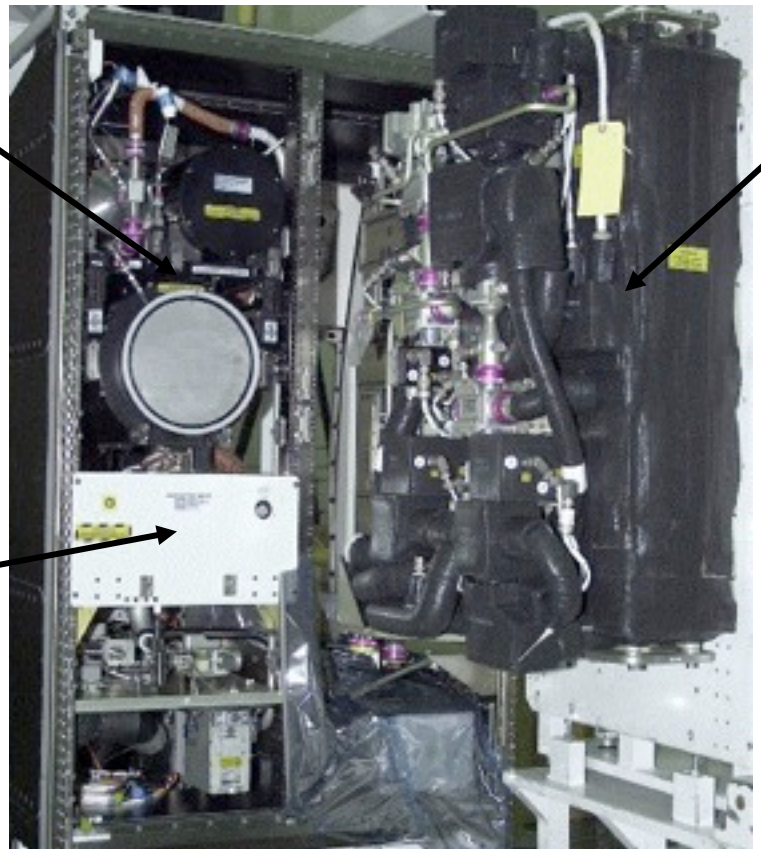


Space Station Atmosphere Revitalization

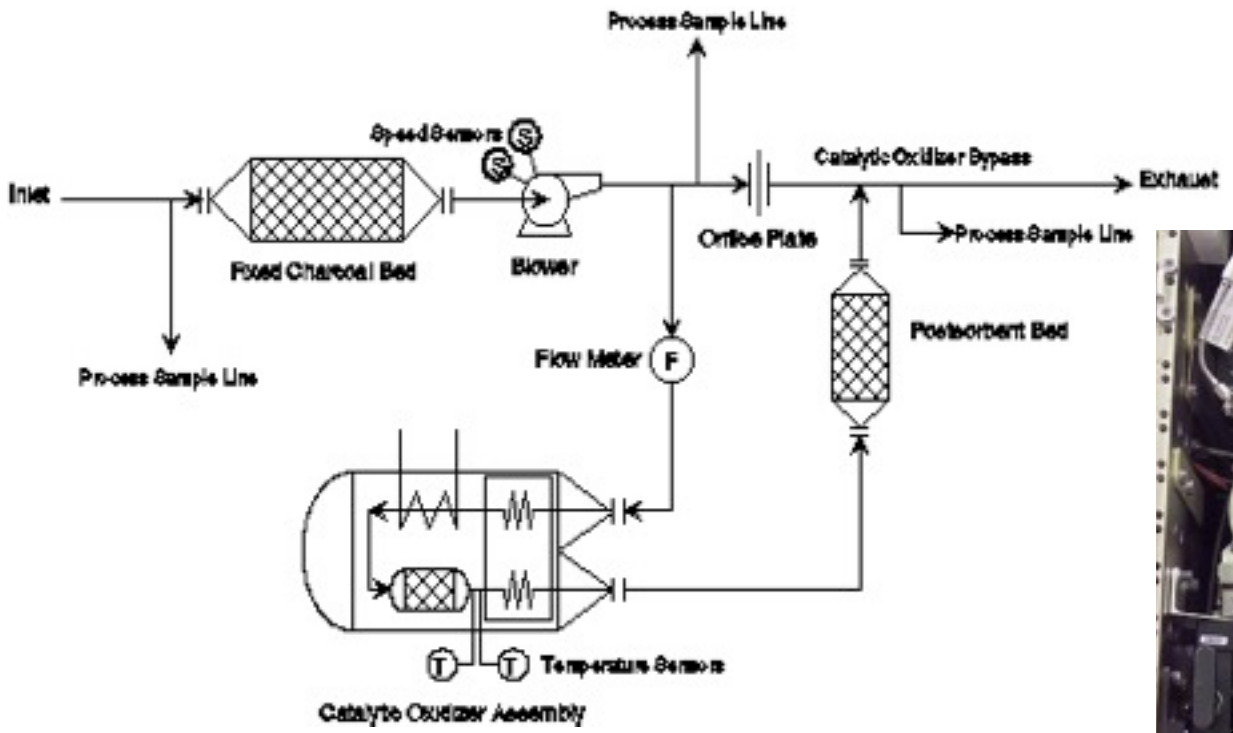
TRACE CONTAMINANT CONTROL SUBASSEMBLY

CO_2 REMOVAL ASSEMBLY

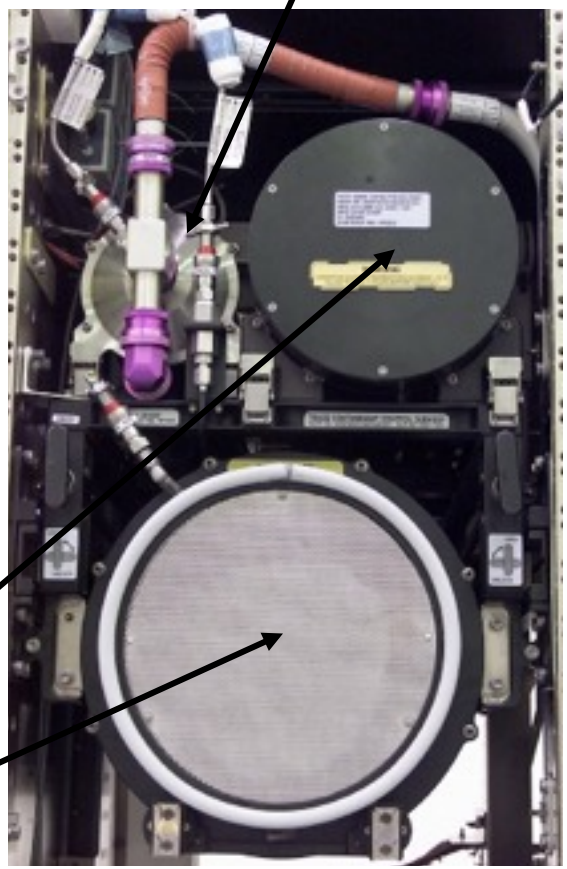
MAJOR CONSTITUENT ANALYZER



ISS TRACE CONTAMINANT CONTROL



POSTSORBENT BED



THERMAL CATALYTIC OXIDIZER

CARBON BED

Microbial Challenges in Space

- **Challenges with monitoring in-flight include:**
  - » Viable vs non-viable microorganisms
  - » Analysis of planktonic microorganisms vs. biofilm
  - » Limited amount of samples
  - » Expendables (waste generation)
  - » Consumables (reusable is preferred)
  - » Low power consumption
  - » Equipment size
  - » Non-hazardous reagents
  - » Non-generation of hazardous waste
  - » Calibration (positive/negative controls?)
  - » Cleaning/disinfection of the sample collection areas
  - » Maintenance/repairs
  - » Upgrade as needed

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22